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THE GROWTH OF GEOLOGICAL IDEAS.

The Founders of Geology. By Sir Archibald Geikie. Pp. x + 297. (London: Macmillan and Co., Ltd., 1897.)

THE truths of science cannot be more impressively taught than by a sketch of the process by which the knowledge has been arrived at, and in no way can that history be more forcibly conveyed than in the biographies of those pioneers who first interpreted the phenomena for us. We may have wondered why the truth was not sooner grasped, but by this method of treating the subject we see what imperfection of evidence or prejudice stood in the way, and learn to appreciate the true spirit of original research which eventually rises above and overcomes all difficulties.

Sir Archibald Geikie has given a sketch of the founders of geology in his, now happily well-known, lucid style. It is necessarily only a selection, and accident or design has led him to make such a selection of points in the development of the subject as has enabled him to write what may be called an "appreciation" of the French school of geologists, and to dwell very fully on the work of some of them whose claims to recognition have hitherto been too much overlooked.

In the earlier stages of research all those who studied the composition of the earth's crust were called mineralogists, and any stony fragments which they dug out of the earth were their fossils. When men began to distinguish between bodies of organic and inorganic origin, they spoke of the pieces of rock and other mineral matter as *native* fossils, considering them as part of the original mass, while they called the remains of plants and animals *extraneous* fossils. It was only in comparatively recent times that the word fossil was applied exclusively to the remains of organisms. When the older writers speculated upon the manner in which the earth's crust had been brought into its present condition, they entitled their results "theories of the earth," which corresponded generally to our modern works on the principles of geology. Though they too often generalised on insufficient data, or wrested their judgment to support an early-formed opinion, they all pretended that their theories were founded on the study of nature; but we find many a good observation and sound inference buried under such a load of bad reasoning, and accompanied by such a cloud of foolish observations, that the writer's credit as a witness was destroyed, and even what was good in him lost sight of.

Our author passes with very brief notice over all the writers earlier than the eighteenth century, and devotes the greater part of his first lecture to a sketch of the work of Guettard: in a few clever touches he brings before us the personality of that remarkable man. Guettard first put into practice the proposal made by Lister in 1683, and constructed a map on which he showed the general surface distribution of the various kinds of rock as they occurred in broad belts in and around the Paris Basin, and even marked on it the places where he had found fossils. Later on, when a good topographical map of France had been produced, he indicated on it the characters of the rock over a very large area, completing the mineralogical survey of no fewer than sixteen sheets of the map. This was a work of great labour, and one involving very close observation, especially as he does not seem to have had any clear idea of the sequence of formations or of geological structure to guide him. Guettard was the first to recognise the ancient volcanoes of Auvergne, and deserves great credit for his able memoir on the meaning of the occurrence of the remains of shells and other organisms in the rocks. But the battle had long been raging between those who maintained that the fossils were mere *lusus naturæ*, and those who held that they represented plants and animals which once lived under conditions analogous to those of recent times, and were buried, as are dead organisms, in the mud and sand of to-day. In this long controversy many Italian and English geologists did good service, notably Agostino Scilla and Dr. John Woodward, who combated especially the erroneous views of Dr. Elie Camerarius; and although their work was hampered by the attempt to accommodate all their explanations to the received interpretation of the Scriptural account of the deluge, still the search for facts to support their theories helped on the work by calling attention to phenomena which might otherwise have long passed unobserved.

In his second lecture our author gives a sketch of the life and work of Desmarest. He tells us of the difficulties and struggles of his early life; of his official work in connection with the efforts made by the French Government in the middle of the last century to develop the industries of the country; and of the influence which the eloquent writings of Buffon had upon him. Desmarest was struck by the correspondence between the opposite cliffs of France and England which had already been pointed out by Guettard, and still earlier by Verstegan. Supporting by biological evidence the idea thus suggested, Desmarest arrived at the conclusion that the channel which now separated them had been cut by the currents of the sea.

His official duties necessitated much travel, but in the intervals of leisure he revisited and more closely examined localities which suggested subjects for further research. In this way he was led to study the origin of basalt, which had been a fruitful theme of controversy for many a long year. He noticed the prismatic structure of the basalts of Auvergne, and recognised them as ancient lavas, and, from descriptions of the general appearance of the columnar rocks of the Giant's Causeway, and an examination of hand specimens, he inferred that they were the same.

He explained the origin of valleys by referring them to the action of the streams which flow in them. This view had evidently been present to the mind of Avicenna, who in the tenth century maintained that mountains were made to stand out by the excavation of the valleys between them, while our great naturalist Ray dwelt upon the operation of streams in the degradation of the land, pointing out that the land must necessarily be eventually reduced below sea level by such agencies.

We are told how from an examination of volcanic phenomena, and in the attempt to correlate them, Desmarest was led to generalise upon the relation of the volcanic to the sedimentary rocks. He also constructed a map which, however, was not published till after his death. He has left many published works which attest his power, his accuracy of observation, and his judgment.

We have, then, an interesting account of the circumstances which led to the systematic exploration of Russia and the part played in it by Pallas, who, among other important observations, clearly recognised a geological sequence in passing from the centre to the outside of a mountain chain.

The rise of the modern spirit of mountaineering is dated from the time of de Saussure, who described so well the geological structure of the Alps, and whose sections of violently folded rocks anticipated so much of the recent work on that region, and whose experiments on the reduction of granite and basalt to a glassy rock by fusion and rapid cooling marked the commencement of experimental geology.

Our author then traces the development of the doctrine of the geological sequence of rocks as distinguished by their lithological character, towards which much had already been done, especially by the Wernerian school, and also the order of their formation as indicated by the succession of organic life buried in or associated with them, and differing in character at different periods of the world's history. The controversy as to the true nature of fossils, which has been referred to above, shows that importance had long been attached to them as a means of interpreting the history of the earth.

We have in the third lecture an account of Werner, the eponymous hero of a theory and a time. The great controversy between the Neptunists and the Vulcanists set men to search for facts in support of their respective views; and though a wrong working hypothesis may often have coloured the vision and warped the judgment, still the indications offered helped other less prejudiced men along lines where inquiry was fruitful. The Wernerian saw basalts interstratified with fossiliferous rocks, and apparently forming one member of a fossiliferous series, while others traced lava-flows with columnar structure from the crater to the sea, and saw how they might rest on ancient sediments and be themselves covered by newer deposits. Werner was wrong about his basalt, but he had introduced a greater care in investigation and a greater precision of description, and, above all, had so insisted upon the doctrine of geological succession that he placed geology upon a sounder basis than it had hitherto ever occupied.

Von Buch did much to free the scientific world from the tyranny of an uncompromising Neptunism by his demonstration of the constant occurrence of earth-movements down to quite recent times, as well as by many other independent researches recorded in numerous memoirs, and embodied in a large geological map of Germany.

If we give de Saussure credit for originating experimental geology, we must give Hutton a foremost place among those who insisted upon the importance of observation in the field. He was a man of wide interests and varied attainments. He realised the importance of Geology to Agriculture, and published works on "The Principles of Knowledge" and "The Progress of Reason from Sense to Science and Philosophy," this last title reminding us of Agostino Scilla's "La vana Speculazione disingannata dal Senso." The aims of both writers were the same, though Hutton got nearer the mark than his predecessor. In tracing the history of an idea, how often we find that the man who gave it to the world, in what we may call an available form, was not the man with whom it really originated. Take, for instance, the view that the action of heat in fusing material is directly influenced by the amount of pressure to which the body is subjected. This is quoted now with references to Sir James Hall, to Fairbairn and Hopkins, and others. But it was one of Hutton's fundamental doctrines, and Hutton got it from his friend Dr. Black, a sound chemist and shrewd experimentalist.

Hutton's first principle was that "no powers are to be employed that are not natural to the globe, no action to be admitted of except those of which we know the principle, and no extraordinary events to be alleged in order to explain a common appearance."

There are many men of note in our day who, going with the swing of the pendulum, as it were, believe in the greater intensity of the operations of nature in past ages, and still within the periods of which we have records in the sedimentary rocks. The phenomena which suggest this view may be reconciled to the strictest uniformitarianism by the doctrine that local catastrophic action is not inconsistent with continuity of causation.

Several distinguished French geologists, about the end of the last and the beginning of the present century, insisted upon the doctrine of stratigraphical sequence as fundamental, and this was soon found to involve the opinion that there was a definite order of succession among organic remains also. In England, while Giraud Soulavie was still a child, and before Cuvier or Brongniart were born, John Michell, Woodwardian Professor of Geology in the University of Cambridge, gave a clear account of the stratified arrangement of the rocks of England, and by his illustrations showed that he understood the principles of geological structure. "Let a number of leaves of paper," said he, "of several different sorts or colours, be pasted upon one another; then, bending them up into a ridge in the middle, conceive them to be reduced again to a level surface, by a plane so passing through them as to cut off all the part that has been raised. Let the middle row be again raised a little, and this will be a good general representation of most, if not all, large tracts of mountainous countries, together with the parts adjacent, throughout the whole world. From this formation of the earth it will follow that we ought to meet with the same kinds of earths, stones and minerals, appearing at the surface in long narrow slips, and lying parallel to the greatest rise of any long ridge of mountains; and so, in fact, we find them."

Then came William Smith, who based all his classifications on the "strata identified by their organic fossils." Sedgwick, who in early life had been the companion of Smith in some of his excursions in the north of England, was so impressed by the importance of the methods of geological research employed by Smith, that he spoke of him on one occasion before the Geological Society as "the Father of English Geology."

The next and last lecture brings us down to recent times, and the men whom many of us knew. In it we are told of the establishment of the Cambrian, Silurian and Devonian systems by Sedgwick and Murchison; of the discovery that glacial ice once gathered on the mountains of the British Isles; of the coordination of the wisdom of many observers by Lyell and Darwin in the enunciation of the great laws which guide the development of the organic and inorganic world; of the practical application by Nicol and Sorby of chemical and microscopic analysis to the identification of the minerals which make up the rocks, and often to the detection of their mode of aggregation.

The old controversy between Sedgwick and Murchison is introduced with a very skilful relative depreciation of Sedgwick; but perhaps the last has not been heard of that question, and it may yet be acknowledged that whereas the Arenig, Bala, and May Hill series were first clearly defined by Sedgwick, and placed in their true relative positions ("Life and Letters of Sedgwick," vol. i. 529-531; vol. ii. 510-563), the Llandeilo and Caradoc series were placed in their wrong order, and had the wrong fossils assigned to them in the "Silurian System" of Murchison, while the May Hill series was then unrecognised by him. Sir Archibald Geikie very fairly says that the middle disputed series must be either Upper Cambrian or Lower Silurian, and is unwilling to admit the new term Ordovician proposed for it.

Geologists owe a debt of gratitude to Mrs. George Huntington Williams, who founded the lectureship in memory of her distinguished and much lamented husband, the late Professor of Geology in the Johns Hopkins University. They will also accord their thanks to those who selected the first lecturer, and to him for his choice of a subject. T. MCKENNY HUGHES.

THE TWO BONDS.

Memorials of William Cranch Bond and George Phillips Bond. By Edward S. Holden. Pp. 296. (New York: Lemcke and Buechner, 1897.)

IN these days when one is rather inclined to forget who were the pioneers of astronomy in different countries, it is interesting to be able to obtain a volume in which are described the lives, the difficulties to be surmounted, and the success attained by those who have been in these critical positions. The two Bonds—William Cranch and George Phillips, father and son—may be regarded as the first important contributors towards the early history of astronomy in America; and as they were the first two directors of the now well-famed Harvard College Observatory, the earliest founded of any college observatory in the United States, an account of their lives and work is very welcome.

The present volume purposes to afford such information, and Prof. E. S. Holden, and those who have helped him, deserve great credit for this valuable contribution to the history of astronomers. Prof. Holden, as he tells us, became acquainted with the Bonds in his youth, and in the preface he speaks of the unfailing kindness which he and his young friends received at their hands when at the observatory. "It has been my fortune," he says, "as an observer, to repeat some parts of his (George Bond's) work, and to obtain in this way an even more accurate judgment of his persistent thoroughness."

William Cranch Bond's father was a true Cornishman, and it is said that the family never ceased to regret their immigration to America. "A loyal love of England was characteristic of the family for many years. In household customs, manners and traditions they were thoroughly English down to very recent days."

William at an early age turned his attention to astronomy, and when only fifteen years old (1804) constructed an excellent chronometer, and also a quadrant which proved a very serviceable instrument. His taste for mechanical contrivances was considerable, and, as is now well known, he became very distinguished in this direction. Much interesting information is brought together in this volume, which shows that William Bond's career was by no means a smooth one, although it was rewarded with great success. The chronograph, now an important adjunct to meridional work, we owe to his mechanical ingenuity, and it is interesting to note that he was the first American to be elected a Foreign Associate of the Royal Astronomical Society.

William's son, George Phillips, was perhaps even more remarkable than his father in the amount of work which he accomplished. His *Magnum opus* on the great comet of Donati is perhaps the best known of his contributions, but there are others which were of nearly equal importance. It may be mentioned here that he was awarded the gold medal of the Royal Astronomical Society for the splendid memoir just referred to, but the official notification of the award reached America some days after his death. The nebula of Orion was minutely examined by him in the winters of 1857-8-9, in order to check the drawing made by his father, and investigate the truth of the remarks of Otto Struve, who criticised the positions of the stars in the engraving. This memoir is also of considerable importance, and illustrates the thoroughness which he displayed in his observational work. George Bond's forecast of the future of photography in its application to celestial physics has shown that he thoroughly understood the whole question, and, as Prof. Holden remarks, "he is the father of celestial photography."

The volume before us contains several interesting extracts from the diaries of George Bond, which include many important facts about his life. The extracts from his notes, made during two visits to Europe in 1851 and 1863, will be found very pleasant reading, as Bond visited most of the important observatories on this side of the Atlantic. His interviews with and descriptions of the astronomers of that day abound with interesting matter. In an account of his visit to Paris, he says about Leverrier:

> "In the frankness of his manners, in the absence of all *assumed* dignity, and in other points of resemblance, he is not unlike Mr. Adams. His straightforward way of expressing himself, and absence of all ostentation, render him what I should call accessible."

These diaries are followed by a collection of George Bond's correspondence, while the last chapter is devoted to an account of the scientific work accomplished by both the father and son. A useful appendix is added